President, to distribute copies of the Memoirs to the Fellows of the Academy resident in foreign countries as they shall deem expedient.'

3. " That five hundred copies of the fourth volume (New Series) be printed, of which one hundred shall be furnished to the authors of the memoirs respectively, for immediate distribution."

Three hundred and fourteenth meeting.

January 2, 1849. — MONTHLY MEETING.

The PRESIDENT in the chair.

Dr. Charles T. Jackson stated that he had discovered the presence of manganese in the water of streams, &c., almost universally. He had detected it in water from the middle of Lake Superior, in Cochituate water, &c. It has usually been regarded as iron in previous analyses. He regarded the observation as having an important bearing in accounting for the deposits of bog manganese at the outlets of lakes and in bogs, as well as for the source of the oxide of manganese in the blood.

Dr. Jackson also remarked upon the importance of having permanent marks fixed along our coast, at mean low water, to serve as a future indication in respect to the elevation or subsidence of the land. It was thought that the proper observations might best be made, and the marks fixed, by the United States Coast Survey. On motion of Dr. Jackson, a committee, consisting of Dr. Jackson, Mr. Desor, and Dr. Gay, was appointed to confer with the proper authorities upon this subject.

Professor Peirce presented a memoir entitled " Researches in Analytical Mechanics. No. I. Upon the Fundamental Principles of Mechanics." In this memoir, the various principles which have been proposed and adopted as a basis of the science are discussed historically and philosophically, and a new form is proposed, which is thought by the author to be more general, and less exceptionable than the others which have been given. " A system of bodies in motion," he re-

marked, "must be regarded mechanically as a system of forces or powers which is a perfect representative of all the single powers of which the system is compounded, and this, too, at whatever time or times the component powers may have been introduced into the system. The question of the simultaneous introduction of the partial powers is of no importance. Any power which is at any time communicated to the system is preserved in the system unchanged in amount or direction."

Dr. B. A. Gould, Jr., presented a discussion of the observations of the planet Metis, with a determination of its orbit, accompanied by a computation of the subsequent perturbations of the orbit, and an ephemeris.

"All observations known to me have been used, with the exception of a few extrameridional ones at times when meridian observations were numerous. They are as follows, — corrected for parallax and reduced to Berlin mean time and decimals of a day.

"OBSERVATIONS OF METIS, 1848.

No.	Mean Berlin Time.		α	δ	Place.	Ast. Soc. Not. VIII.	Ast. Nachr. XXVII.
1	Apr. 26.510104	E.	223° 53′ 38″.7	—12° 31′ 46″.3	Markree	p. 175	p. 334
2	.584930	M.	52 29.1	31 33.1	"	174	192,331
3	.633460	E.	51 48.9	31 26.9	"	175	334
4	28.478664	E.	24 22.2	26 31.6	"	175	334
5	29.488233	E.	9 11.5	23 50.0	"	175	334
6	30.499384	E.	222 53 49.2	20 52.4	Camb. E.	177	
7	.547582	M.	53 5.2	20 46.6	"	176	
8	May 1.511634	E.	38 28.0	18 10.3	"	177	
9	.544158	M.	38 5.4	18 2.5	"	176	
10	2.540726	M.	22 52.6	15 25.3	"	176	
11	.566836	E.	22 26.4	15 25.4	"	177	
12	3.444364	E.	9 12.6	13 8.0	Markree	175	334
13	.517743	E.	8 1.6	12 52.8	Camb. E.	177	
14	.537294	M.	....	12 47.1	"	176	
15	4.533866	M.	221 52 36.0	10 10.4	"	176	
16	.571414	E.	52 5.2	10 8.4	"	177	
17	5.477282	E.	38 19.5	7 47.3	Markree	175	334
18	.503099	M.	37 54.5	7 42.7	Hamburg	177	202
19	.503183	M.	37 54.8	7 37.7	Altona		209
20	.530446	M.	37 37.5	7 32.6	Camb. E.	176	
21	.554108	M.	37 8.4	7 33.0	Markree	174	331
22	6.499673	M.	22 50.2	5 12.1	Hamb.	177	202
23	.499761	M.	22 54.5	5 6.6	Altona		209
24	.527015	M.	22 27.0	5 2.8	Camb. E.	176	
25	.588627	E.	21 30.0	4 46.6	"	177	
26	7.486770	M.	7 54.5	2 37.9	Berlin		222
27	.496248	M.	7 48.5	2 40.9	Hamb.	177	202
28	.496322	M.	7 51.6	2 36.6	Altona		209
29	.523590	M.	7 25.8	2 31.4	Camb. E.	176	
30	8.483351	M.	220 52 59.3	—12 0 11.8	Berlin		222

No.	Mean Berlin Time.		α	δ	Place.	Ast. Soc. Not. VIII.	Ast. Nachr. XXVII.
31	May 8.492829	M.	220° 52′ 54″.6	—12° 0′ 14″.1	Hamburg	p. 174	p. 202
32	.492913	M.	52 54.0	0 7.6	Altona		209
33	.520168	M.	52 26.4	—11 59 55.2	Camb. E.	176	
34	9.479936	M.	38 10.7	57 43.7::	Berlin		222
35	.489411	M.	38 0.4	57 47.6	Hamb.	177	202
36	.489497	M.	38 1.8.·.	57 44.6.·.	Altona		209
37	.489500	M.	38 6.6	57 43.4	Göttingen		236
38	.516753	M.	37 35.7	57 34.9	Camb. E.	176	
39	.540422	M.	37 17.2	57 35.9	Markree	174	331
40	10.476524	M.	23 26.7	55 21.9	Berlin		222
41	.486003	M.	23 19.3	55 24.4	Hamb.	177	202
42	.486086	M.	23 18.8	55 14.8	Altona		209
43	.513341	M.	22 51.0	55 16.4	Camb. E.	176	
44	.537012	M.	22 34.6	55 14.8	Markree	174	331
45	11.473115	M.	8 44.3	52 58.4	Berlin		222
46	.482199	M.	8 43.5	52 56.3	Altona		209
47	.482597	M.	8 41.5	53 2.1	Hamb.	177	202
48	.482680	M.	8 40.5	53 5.5	Göttingen		236
49	.509936	M.	. . . . .	52 59.7	Camb. E.	176	
50	12.479200	M.	219 54 15.5	50 50.2	Hamb.	177	202
51	.479282	M.	54 13.2	50 40.8	Altona		209
52	.488501	E.	54 7.2	50 52.9	Markree	175	334
53	.506536	M.	. . . . .	50 40 1	Camb. E.	176	
54	.530147	M.	53 27.0	50 38.2	Markree	174	331
55	.549492	E.	53 12.0	50 37.6	Camb. E.	177	
56	13.466315	M.	39 58.2	48 34.0	Berlin		222
57	.475803	M.	39 47.3	48 34.8	Hamb.	177	202
58	.475890	M.	39 52.7	48 30.1	Altona		209
59	.477231	E.	39 49.9	48 37.0	Markree	175	334
60	.503144	M.	39 23.4	48 23.7	Camb. E.	176	
61	.526815	M.	39 7.2	48 26.7	Markree	174	331
62	14.462948	M.	25 46.1	46 27.1	Berlin		222
63	.472416	M.	25 37.0	46 21.9	Hamb.	178	202
64	.472508	M.	25 43.1	46 20.4	Altona		209
65	15.469027	M.	11 19.0	. . . . .	Hamb.		202
66	.496378	M.	. . . . .	44 3.8	Camb. E.	176	
67	.546605	E.	10 37.5	44 15.3	"	177	
68	16.516602	M.	218 57 13.9	42 17.0	Markree	174	331
69†	.540250	E.	56 51.9	42 12.2	Camb. E.	177	
70†	18.485982	E.	30 31.8	38 33.5	Markree	175	334
71	.486306	M.	. . . . .	38 28.9	Camb. E.	176	
72†	19.474176	E.	17 36.3	36 48.1	Markree	175	334
73	.506647	M.	17 8.8	36 47.0	"	174	331
74	21.448990	M	217 52 13.5	33 36.7	Hamb.	178	270
75	22.436212	M.	39 57.5	32 8.0	Berlin		254
76	.445297	M.	39 56.9	32 4.0	Altona		209
77	.445678	M.	39 50.4	32 8.4	Hamb.	178	270
78	.473033	M.	. . . . .	32 7.8	Camb. E.	176	
79	.496704	M.	39 12.9	32 3.4	Markree	174	331
80	23.442006	M.	27 49.7	30 42.1	Altona		209
81	.442400	M.	27 43.2	30 49.4	Hamb.	178	270
82	.469745	M.	27 24.0	30 25.4	Camb. E	176	
83	24.438958	M.	15 56.4	29 20.8	Altona		209
84	.439127	M.	15 58.9	29 28.0	Hamb.	178	
85	.439211	M.	15 58.8	29 25.0	Göttingen		270
86	.587937	E.	14 14.4	29 13.5	Camb. E.	177	
87	25.537044	E.	3 15.1	27 53.8	Markree	175	334
88	26.432221	M	216 53 17.1	27 3.0	Altona		270
89	.432616	M.	53 11.3	27 1.2	Hamb.	178	270
90	.483278	M.	216 52 30.9::	—11 27 6.0	Markree	174	331

No.	Mean Berlin Time.		α	δ	Place.	Ast. Soc. Not. VIII.	Ast. Nachr. XXVII.
91	May 27.428987	M.	216° 42′ 21″.5	—11° 26′ 3″.8	Altona		p. 270
92	.429382	M.	42 17.7	26 10.8	Hamburg	p. 178	270
93	.456722	M.	41 53.8	26 1.2	Camb. E.	176	
94	29.473979	M.	20 58.5	24 25.7	Markree	174	331
95	.533195	E.	20 25.3	24 28.5	"	175	334
96	.541550	E.	20 24.4	24 34.5	"	175	334
97	30.419771	M.	11 34.9	23 47.2	Hamb.	178	
98	.447118	M.	11 18.1	.....	Camb. E.	176	
99	.507419	E.	10 41.8	23 40.5	"	177	
100	31.443949	M.	1 48.4	23 12.1	"	176	
101	June 1.413445	M.	215 52 49.6	22 42.1	Hamb.	178	
102	.462339	E.	52 25.9	22 41.6	"	178	299
103	2.461270	M.	43 32.2	22 23.7	Markree	174	331
104†	.504320	E.	43 19.0	22 33.2	"	175	334
105	3.477010	E.	35 3.6	22 13.3	Hamb.	178	299
106†	.498423	E.	34 50.1	.22 18.3	Markree	175	334
107	5.428353	M.	19 43.6	.....	Camb. E.	176	
108	.491207	E.	18 56.2	22 8.0	"	177	21
109†	.516247	E.	18 50.5	22 14.6	Markree	175	334
110	.526832	E.	18 48.7	22 20.7	"	175	334
111	6.425267	M	12 0.0	.....	Camb. E.	176	
112	.481021	E.	11 42.6	22 14.1	"	177	
113	.516420	E.	11 32.4	22 11.0	Hamb.		299
114	7.479212	E.	4 51.7	22 31.0	"		299
115	.529944	E.	4 28.9	22 37.1	Camb. E.	206	
116	13.542084	E.	214 31 4.0	26 42.3	"	206	
117	15.553554	E.	23 0.0	29 19.1	Markree		334
118	19.560015	E.	11 46.7	35 37.6	"		334
119	20.425106	E.	10 9.5	36 57.4	Geneva		383
120	.495681	E.	10 0.3	37 17.6	Markree		334
121	21.436715	E.	8 39.0	38 47.8	Geneva		383
122	22.491386	E.	7 26.9	41 5.0	Camb. E.	206	
123	26.464622	E.	6 56.6	50 19 8	Geneva		383
124	28.458603	E.	8 49.8	55 33 8	"		383
125	.467084	E.	8 56.5	55 39.0	"		383
126	.506224	E.	8 50.8	55 34.7:	Markree		334
127	July 3.455846	E.	20 18.9	—12 10 42.7	Geneva		383
128	4.451389	E.	23 40.4	14 2.8	"		383
129	.461157	E.	23 42 7	14 4.9	"		383
130	5.445196	E.	27 24.1	17 27.2	"		383
131	.455880	E.	27 22.6	17 26.4	"		383
132	.495052	E.	27 29.6	17 24.3	Camb. E.	206	
133	.504386	E.	27 33.1	17 39.8	"	206	
134	6.456574	E.	31 32.0	20 56.5	Geneva		383
135	.460596	E.	31 26.9	20 59.7	Camb. E.	206	
136	.446302	E.	31 32.4	20 54.7	Geneva		383
137	8.446739	E.	40 37.0	28 21.8::	"		383
138	.454434	E.	40 39.1	28 14.0	"		383
139	12.447272	E.	215 3 1.1	43 56.0	Camb. E.	206	
140	13.435726	E.	9 10.4::	.....	Geneva		383
141	.470256	E.	9 33.7	48 10.2	Camb. E.	206	
142	15.458790	E.	23 12.9	56 38.3	"	206	
143†	27.443123	E.	217 10 33.4	—13 53 54.9	"	206	
144	Aug. 4.427226	E.	218 43 53 3	—14 36 52.7	"	206	
145	.433155	E.	44 7.3	36 51.4	"	206	

" The letters E. and M. show whether the observation was made with a meridian or with an equatorial instrument.

" The declination of the comparison star Bessel XIV. 424, used at Markree on the 2d, 3d, and 5th of June, is apparently wrong.

Weisse gives	—11°	11′	44″.4
Challis finds	—11	11	33.0
Rümker "	—11	11	41.6

" In the four observations at Markree where the planet was referred to this star, the mean between the declinations given by Professors Challis and Rümker has been assumed for the comparison star, and the planet's south declination therefore diminished by 7″.1.

" In the star to which the planet was referred at Markree on the 18th and 19th of May, the conclusion of Mr. Graham, that there is an error of $4^{s.}$ in the R. A. of 4848 Br. Assoc. Catal., is evidently correct. The observations of Metis on those days harmonize much better with the rest of the series, however, by taking the position of the star there given, with this correction, than by taking the one which Mr. Graham obtained on the 25th of May, and the former has therefore been used for the comparison. The other determination gives, —

	$\Delta\alpha$	$\Delta\delta$
70	—3″.1	+6″.6
72	—9.1	+5.6

" The right ascension of the Cambridge observation of May 16 (A. S. Notices, p. 177) is given $14^{h.}\ 33^{m.}\ 47^{s.}.46$, where the minutes should evidently be 35, instead of 33.

" In the Cambridge observation of July 27, as given in the Notices of the Astr. Soc., p. 206, there is an error in the right ascension of 20 seconds of time. The observation clearly was $14^{h.}\ 28^{m.}\ 42^{s.}.1$.

" Is there not a mistake of $1^{m.}$ in the Hamburg observations of May 15th and June 6th, and the Cambridge Mer. of June 5th ?

" From three normal places for April 28.5, June 16.5, and August 4.5, I have computed three different ellipses, the normal places differing from one another according to the number of observations from which they were constructed. The observations of Professor Challis at Cambridge in England, on the 4th of August, have been of great service, and contributed in a high degree to the precision of the new orbit. The fact that so small and faint an object was observed so near the sun, three weeks after any other published observations, furnishes of itself a sufficient tribute to the skill and unwearied efforts of the observer, and the great power of the Northumberland equatorial. It

is much to be regretted that no observations were made by any of the large Munich refractors, as they might, at the least, have been able to fill out a great part of the series up to Professor Challis's last observation.

" The three orbits are as follows : —

Epoch. June 16.5 Berlin M. T., M. Eq. 1848.0.

	I.	II.	III.
M	157° 6′ 53″.25	156° 15′ 45″.9	156° 8′ 4″.85
☊	68 28 32.6	68 28 3.3	68 27 56.1
π	70 56 50.8	71 35 14.75	71 41 2.2
i	5 35 32.88	5 35 33.4	5 35 34.4
φ	7 2 52.73	7 6 43.85	7 7 14.52
μ	962″.647	963″.244	963″.272

" These three orbits satisfy the series of observations almost equally well, Orbit I. giving the majority of the Right Ascensions somewhat too large, and II. and III. somewhat too small. The sum of the errors is smallest in II., — the sum of their squares in III. The Orbit III. gives the following absolute places, to which is annexed the aberration in decimals of a day.

" METIS. MEAN BERLIN NOON.

Date.	α	δ	Log. Δ	Aberration.
1848.				d.
Apr. 26.0	224° 1′ 6″.3	—12° 33′ 5″.2	0.213024	0.009664
30.0	223 1 14.2	12 22 17.2	.211839	.009638
May 4.0	222 0 33.8	12 11 37.7	.211857	.009639
8.0	221 0 6.8	12 1 22.7	.213069	.009666
12.0	220 0 56.8	11 51 50.5	.215446	.009719
16.0	219 4 7.2	11 43 17.5	.218948	.009797
20.0	218 10 30.2	11 35 56.2	.223502	.009900
24.0	217 20 55.0	11 29 59.4	.229049	.010028
28.0	216 36 1.8	11 25 37.2	.235479	.010178
June 1.0	215 56 27.9	11 22 58.3	.242729	.010349
5.0	215 22 36.8	11 22 9.1	.250679	.010540
9.0	214 54 52.7	11 23 15.3	.259229	.010750
13.0	214 33 22.8	11 26 16.3	.268280	.010976
17.0	214 18 9.7	11 31 13.1	.277725	.011217
21.0	214 9 12.0	11 38 2.7	.287490	.011473
25.0	214 6 25.3	11 46 38.4	.297486	.011740
29.0	214 9 42.9	11 56 58.2	.307650	.012018
July 3.0	214 18 56.6	12 9 7.4	.317909	.012304
7.0	214 33 53.9	12 22 52.6	.328211	.012600
11.0	214 54 21.6	12 38 7.5	.338488	.012902
15.0	215 20 3.5	12 54 46.5	.348707	.013209
19.0	215 50 41.2	13 12 36.7	.358819	.013520
23.0	216 26 6.5	13 31 36.2	.368805	.013834
27.0	217 6 2.6	13 51 40.7	.378635	.014150
31.0	217 50 18.7	14 12 41.8	.388286	.014469
Aug. 4.0	218 38 41.8	14 34 31.9	.397732	.014787
8.0	219 30 59.6	—14 57 6.7	0.406956	0.015105

" The comparison of this ephemeris with observation is contained in the following table.

" Comparison of Orbit III. with Observation.

C. — O.

Obs.	Δα	Δδ	Obs.	Δα	Δδ	Obs.	Δα	Δδ	Obs.	Δα	Δδ
1	+3″.6	+ 2″.0	38	+ 1″.2	— 5″.8	74	— 3″.3	— 1″.0	110	— 8″.1	+ 1″.9
2	+6.7	+ 1.1	39	— 1.4	— 1.9	75	— 2.9	— 1 1	111	+ 6.3	. . .
3	+3.6	+ 2.6	40	— 2.4	— 1.9	76	— 9 1	— 4.3	112	+ 0.6	— 0.4
4	—1 8	+ 4.2	41	— 3.3	+ 2.0	77	— 2.8	+ 0.1	113	—27.4	— 9.4
5	—4.5	+ 7.5	42	— 3.0	— 7.6	78	. . .	+ 3.6	114	— 3.1	— 1.1
6	+0.9	— 6.3	43	+ 0.6	— 2.1	79	— 3.1	— 0.4	115	— 2.4	— 1.9
7	+1 2	— 1.1	44	— 3.8	— 0.4	80	— 8.1	— 2.4	116	— 3.9	— 6.6
8	+2.6	— 5.3	45	+ 1.2	— 6.0	81	— 1.9	+ 4.9	117	— 1.4	+ 7.3
9	—4.3	— 7.7	46	— 3.1	— 6.7	82	— 2.5	—16.8	118	— 3.0	+16.3
10	+0.5	— 5.3	47	— 4.4	— 0 8	83	— 4.0	— 5.8	119	— 1.2	+ 2.7
11	+3.1	— 1.0	48	— 3.3	— 1.6	84	— 6 7	+ 1.5	120	+ 0.3	+14.0
12	—2.4	+ 1.0	49	. . .	+ 0.6	85	— 6.5	— 1.3	121	— 1.6	— 3.6
13	+0.8	— 2.5	50	— 7.0	+ 3.2	86	— 6 2	— 1.9	122	+ 0.7	+ 3.0
14	. . .	— 5.1	51	— 4.8	— 6.1	87	— 2.9	—13 3	123	— 1.5	+ 7.5
15	+0.7	— 4.1	52	— 1.9	+ 7.2	88	— 8.1	— 5.9	124	+ 5.6	+ 3.9
16	—2.7	+ 1.4	53	. . .	— 3.1	89	— 2.6	— 7.6	125	— 0.6	— 0.0
17	—1.0	— 1.0	54	— 2.6	— 1.9	90	+ 3.6	+ 0.4	126	+ 7.8	— 4.8
18	+0.5	+ 1.6	55	— 4.4	+ 0.2	91	— 5.8	— 5.2	127	+ 1.2	— 1.5
19	+0.1	— 6.4	56	— 1.7	— 2.1	92	— 3 2	+ 1.7	128	— 0.3	— 0.2
20	—7.3	— 6.5	57	+ 1.0	— 0.3	93	+ 2.9	— 6.3	129	— 0.5	— 0.1
21	+0.3	— 3.4	58	— 4.5	— 5.0	94	— 3.7	— 1.0	130	— 2.5	+ 1.4
22	+0.4	+ 1.3	59	— 2.8	+ 2.3	95	— 6.3	+ 4.4	131	+ 1.5	— 1.5
23	—3.9	— 4.4	60	+ 0.3	— 7.2	96	—10.6	+10.6	132	+ 3.5	—11.9
24	—1.1	— 3.8	61	— 2.7	— 1.5	97	—13.8	— 1.7	133	+ 1.7	+ 1.7
25	+0.1	—10.5	62	+ 0.2	— 0.9	98	— 2.1	. . .	134	— 2.4	— 2.0
26	+3.4	— 3.4	63	+ 1.2	— 4.9	99	— 1.4	— 5.0	135	+ 3.8	+ 0.1
27	—2 5	+ 1.2	64	— 5 1	— 6.4	100	— 5 0	— 2.2	136	— 0.4	— 5.7
28	—5.9	— 3.0	65	+19.3	. . .	101	— 2.7	— 6.3	137	+ 1.1	+ 6.5
29	—0.9	— 4.2	66	. . .	—15.8	102	— 5.2	— 5 6	138	+ 1.2	— 3.1
30	+2.9	— 0.7	67	— 3.5	+ 2.0	103	— 2.4	— 2.5	139	— 2.1	— 2.7
31	—1.8	+ 3.1	68	— 5.6	— 0 0	104	—11.8	+ 7 8	140	+ 8.5	. . .
32	—1.3	— 3.3	69	— 2 2	— 2.2	105	—10.3	— 1.4	141	— 1.3	— 2.8
33	+1.3	—11.9	70	— 1.5	— 1.6	106	— 7.6	+ 3.8	142	+ 0.5	— 4.0
34	—1.0	— 3.0	71	. . .	— 6 2	107	—17.2	. . .	143	+ 2.4	+ 1.4
35	+0.6	+ 2.4	72	— 7.4	— 2.6	108	+ 1.5	— 3.6	144	+ 4.8	+ 1.2
36	—0.9	— 0.6	73	— 5.5	— 0.3	109	— 4.1	+ 3.3	145	— 4.7	— 1.1
37	—5.5	— 1.7									

" For this orbit the perturbations by Jupiter, since the opposition of 1848, have been computed. The influence of Saturn was found quite unappreciable, and that of Mars very insignificant, although the latter planet will be nearly in heliocentric conjunction with Metis during the month of April next. Their difference of latitude is, however, very considerable.

" The variations of the osculating elements are as follows. They are to be algebraically added to the elements in Orbit III.

Date.	Δi	$\Delta \Omega$	$\Delta \varphi$	$\Delta \Pi$	$\Delta \mu$	$\iint \frac{d\mu}{dt^2}$	ΔL
1848, July 28.5	—0″.33	+0″.67	— 7″.49	+17″.32	—0″.049	—0″.76	—0″.29
Sept. 8.5	0.70	0.82	15.14	29.38	—0.097	3.82	2.01
Oct. 20.5	1.09	+0.36	22.73	35.87	0.143	8 85	5.06
Dec. 1.5	1.48	—0 76	30.38	37.92	0.186	15.78	9.33
1849, Jan. 12.5	1.87	2.55	37.28	34.88	0.226	24.46	14.69
Feb. 23 5	2.23	4.99	43.62	28.76	0.260	34.68	20.97
Apr. 6.5	2.54	8.02	49.34	21.12	0.288	46.22	28.01
May 18.5	2.81	11.54	54.43	11.65	0 309	58.81	35.59
June 29.5	3.00	15.40	59.97	6.16	0.323	72.12	43.51
Aug. 10.5	3.13	19.46	64 08	4 12	0.351	86.32	51.43
Sept. 21.5	3.17	23.54	67.96	6.69	0.345	100.92	59.25
Oct 23 5	—3.14	—27.44	—71.67	+16.71	—0.332	—116.08	—66.68

" Hence result the following osculating elements for April 6.5 : —

" METIS.

1849. April 6.5, Mean Equinox 1849.0. M. B. T.

M	234°	45′	32″.9		
L	306	27	46.5		
Ω	68	28	38.5		
Π	71	42	13.7		
i	5	35	31.9	Log. μ	2.9836193
φ	7	6	25.18	Log. a	0.3775915
μ		962″.985		Log. e	9.0924492

"These elements give the following ephemeris for the reappearance of Metis in 1849. The great diversity of the elements calculated from normal places so little different would of itself indicate that great exactness cannot be expected. And, were it not so, the unavoidable insecurity of the extrameridional observations at the discovery, and immediately before the disappearance, of the planet, would warn us to expect at least an uncertainty of one or two minutes in the predicted place.

" METIS. MEAN BERLIN MIDNIGHT.

Date.	α	δ	Log. Δ	Aberr. Time.
1849. Mar. 15	310° 36′ 51″	—21° 26′ 41″	0.499212	d. 0.018680
16	311 1 45	21 21 50	.497747	
17	311 26 34	21 16 58	.496262	.018553
18	311 51 16	21 12 5	.494760	
19	312 15 53	21 7 10	.493240	.018425
20	312 40 24	21 2 15	.491702	
21	313 4 49	20 57 18	.490147	.018294
22	313 29 9	20 52 20	.488575	
23	313 53 24	20 47 21	.486986	.018161
24	314 17 32	20 42 20	.485379	
25	314 41 34	—20 37 20	0.483756	0.018027

Date.	α	δ	Log. Δ	Aberr. Time.
1849.	° ′ ″	° ′ ″		
Mar. 26	315 5 30	—20 32 19	0.482116	d.
27	315 29 19	20 27 17	.480459	0.017890
28	315 53 2	20 22 15	.478784	
29	316 16 38	20 17 13	.477091	.017752
30	316 40 7	20 12 10	.475380	
31	317 3 29	20 7 7	.473651	.017612
Apr. 1	317 26 44	20 2 4	.471904	
2	317 49 52	19 57 1	.470140	.017470
3	318 12 54	19 51 58	.468358	
4	318 35 48	19 46 55	.466559	.017327
5	318 58 35	19 41 53	.464742	
6	319 21 16	19 36 51	.462908	.017182
7	319 43 49	19 31 49	.461057	
8	320 6 15	19 26 47	.459188	.017035
9	320 28 34	19 21 47	.457301	
10	320 50 46	19 16 46	.455397	.016887
11	321 12 50	19 11 47	.453476	
12	321 34 46	19 6 48	.451536	.016738
13	321 56 35	19 1 51	.449579	
14	322 18 16	18 56 54	.447604	.016587
15	322 39 50	18 51 59	.445611	
16	323 1 15	18 47 5	.443601	.016435
17	323 22 32	18 42 13	.441573	
18	323 43 42	18 37 22	.439528	.016282
19	324 4 42	18 32 32	.437464	
20	324 25 35	18 27 45	.435383	.016127
21	324 46 19	18 22 59	.433284	
22	325 6 54	18 18 15	.431168	.015971
23	325 27 20	18 13 33	.429034	
24	325 47 37	18 8 54	.426883	.015814
25	326 7 45	18 4 17	.424715	
26	326 27 44	17 59 42	.422530	.015656
27	326 47 34	17 55 9	.420328	
28	327 7 15	17 50 39	.418108	.015498
29	327 26 46	17 46 11	.415872	
30	327 46 8	17 41 45	.413618	.015338
May 1	328 5 20	17 37 23	.411347	
2	328 24 22	17 33 5	.409060	.015178
3	328 43 14	17 28 49	.406755	
4	329 1 56	17 24 36	.404434	.015017
5	329 20 29	17 20 27	.402097	
6	329 38 51	17 16 21	.399743	.014856
7	329 57 2	17 12 19	.397373	
8	330 15 3	17 8 20	.394987	.014694
9	330 32 54	17 4 25	.392584	
10	330 50 34	—17 0 34	0.390165	0.014532

"The elements computed by me on the 28th of May last, and published in No. 639 of the *Astronomischen Nachrichten* (XXVII. p. 237), gave the right ascension, at the beginning of August, a minute and a half of arc too large, and the declination nine seconds too far south. These elements were deduced from meridian observations at an interval of but thirty days, and furnish a strong testimony to the importance of basing the orbits computed from a small arc upon meridian observations alone, if possible."

Professor Lovering read a paper on the "Law of Continuity," and a seeming exception to it, and illustrated it by various magnetical experiments.

"*The law of continuity* supposes that, in the operations of nature, a body passes from one state to another distinct state only by going through all the intermediate states. As to motion, this is obviously true. We cannot conceive of a body getting from one place to another, except by moving, in successive instants of time, through the intermediate positions.

"Leibnitz, who claimed to be himself the originator of this principle, considered it applicable, not only to the position of a body, but to the chemical and physical arrangement of its molecules. He supposed the foundations of this principle to be laid so deep in the arrangements of nature and the structure of the human mind, that man could not, when he reasoned upon the subject, conceive of its non-existence or of any exception to its application. The extreme length to which the law of continuity was pressed by Leibnitz and Bernouilli, in their attempts to demonstrate the laws of mechanics, led Maclaurin and others to reject it altogether. It must be admitted, notwithstanding, that this law of continuity has a firm foundation in truth ; and that, under its guidance, man is put into the right path in the investigation of the plan of nature. The method of analysis which began with Leibnitz and Newton, and which in England has been known under the name of fluxions, rests upon this law of continuity. For it supposes a line to *flow* out from a point, a surface from a line, and a solid from a surface ; and this, like any other motion, involves the law of continuity. If we admit the usefulness of the principle only in cases of motion, we still give it a wide range ; since so many problems, not strictly dynamical, are reduced to cases of motion when investigated by the rules of modern analysis.

"The object of the present communication is not, however, to explain or defend the law of continuity as a sound principle in physical investigation, but to call attention to a few real or apparent exceptions to it with which I have become acquainted in studying the physical forces.

"If we place a bar-magnet on a table, and move over it lengthwise a small compass-needle which is free to move on a horizontal axis only, when this axis is parallel to the axis of the large magnet, the law

of continuity will be observed in the changes of dip in the needle while it moves over the bar. If the needle is placed so that its horizontal axis is at right angles to the axis of the large magnet, then there is a remarkable breach of continuity in the sequences of dip. While moving from one end of the bar to the middle, the needle will be vertical all the time. Suddenly, on passing the middle point, it makes half a revolution, so as to bring the end which before pointed to the zenith towards the nadir. Here, then, in the changes of dip in a needle thus exposed, the law of continuity is not observed. If we substitute for the large magnet the magnetism of the earth, we have the same result. A dipping-needle, placed so that the axis on which it turns is in the magnetic meridian, keeps a vertical position while it is carried from the earth's magnetic poles to the earth's magnetic equator. As it crosses the magnetic equator, its two poles suddenly exchange positions with each other.

" There is one view to be taken of these facts which does not require us to believe that the law of continuity is disturbed. In both cases, the needle is constrained by its axis; for this axis is put in such a position that the whole force of nature is decomposed into two others, one of which is destroyed by the axis. If we take the action of the free force, the law of continuity prevails both in regard to the direction and the amount of the force. Still, this example will show that in the motions of a machine, or in any case where the forces of nature are artificially modified, it is not always safe to assume, in unqualified terms, the applicability of the law of continuity.

" A case can be supposed in which the force of gravity will be found in the same predicament. We cannot make the experiment, but it is not difficult to imagine what the result would be if the experiment were tried. I suppose a small tunnel to be cut from any point on the earth's surface to the centre, and so on to the opposite hemisphere. A plumb-line, if brought to the extremity of this opening, would point to the earth's centre; and, if let down into the opening, would still do so, though with diminished force. If it continued to move along the tunnel, at the instant of passing the earth's centre of gravity its direction would suddenly change 180 degrees. In this case, the law of continuity is observed so far as the intensity of the earth's gravity is concerned, but it is broken in regard to the direction of the force. This must necessarily be the case under the influence of central forces, unless there is combined with them another force, like the projectile force,

which, in the solar system, unites with the former to carry the planet in a continuous curve around its centre of motion. If the force of projection be ever so small, the planet will move in a curve, however elongated, and change its direction gradually, though it may be with all the rapidity of the comet shooting through its perihelion. When the projectile force is nothing, the motion is rectilinear, and the direction alters abruptly. Here, also, the case is made easy, and the authority of the law of continuity vindicated. For in this instance, as in all others where motion, and not simply directive power, is considered, the velocity gradually diminishes, and prepares the way for a new motion in the opposite direction.

"It is well known, that sometimes the law of the forces of nature changes once or more in passing from one condition of nature to another continuously connected with it. Thus the attraction of a solid sphere is as the square of the distance from the centre inversely, so long as the attracted body is on the outside. When the attracted body comes within the surface, the attraction is directly as the distance from the centre. In the case of a hollow shell, the law of its attraction changes more than once. Within the shell, the attraction is constant for all positions. Outside, it obeys the same law as in a solid sphere. In the thickness itself, the attraction is subject to a third law. The centre of gravity of the attracted body will pass abruptly from one to another of these three conditions; but it is not always safe to represent the whole body by its centre of gravity. As the small body is passing through the surfaces of the large one, neither of the three laws stated above is applicable. Probably no single law will follow the body through the various positions involved in the entering of one of the bodies into the other. The law itself probably changes every instant, and thus the three partial laws, which are so discontinuous, and which are derived from a consideration of only the centre of gravity, will appear to be continuously connected when those links which are neglected when we study the motions wholly through the centre of gravity are restored. The mathematical function itself, therefore, if made so general as to include all the conditions of the experiment, might possibly be continuous from first to last. At any rate, if we give full weight to this apparent breach of continuity in the present mathematical expression of the law of attraction, it by no means follows that the body which is attracted and passes into these various exposures will change its velocity abruptly, as it comes under

the sovereignty of one or the other of these laws. The laws may be different, widely different, in themselves, and yet in positions near together each may give a velocity not very different from what the others would have done. Therefore the abrupt change of the law will produce only a gradual change in the velocity of the moving body. This consideration is sufficient to show that the law of continuity is observed, to the exclusion of violent changes in matter. Nevertheless, a mental shock will be occasioned if the law itself shall not appear upon deeper investigation to retain, unbroken and unimpaired, its simplicity and integrity."

Three hundred and fifteenth meeting.

January 31, 1849. — Quarterly Meeting.

The President in the chair.

The Corresponding Secretary read a letter from James Hall, Esq., of Albany, acknowledging the notification of his election as a Fellow of the Academy, and presenting the first volume of his work on the Paleontology of New York.

The Corresponding Secretary also presented from Dr. Bache a copy of his report on the progress of the United States Coast Survey, accompanied by the request that the Academy would submit it to a careful examination, and make such suggestions as might be called for upon the scientific character and value of the survey as now carried on, or which might tend to give greater efficiency to the work. The subject was referred to a committee, consisting of Professor Peirce, Professor Lovering, Mr. Treadwell, and Mr. J. I. Bowditch.

A note from Dr. John Ware, resigning his place on the Rumford Committee, having been read by the President, Mr. Treadwell was appointed to fill this vacancy.

Professor Arnold Guyot, late of Neuchatel, was elected a Fellow of the Academy.

At the request of the committee on the establishment of permanent marks to indicate the water-level on our coast, Lieutenant Davis and Mr. E. C. Cabot were added to the committee.